NITRATE-NITROGEN AND NUTRIENT CONTENTS OF HYDROMORPHIC SOILS UNDER VEGETABLE PRODUCTION IN DELTA NORTH AGRO-ECOLOICAL ZONE OF NIGERIA

BY

YOUNG ELOHOR
PG/11/12/205053

A DISSERTATION SUBMITTED TO THE POSTGRADUATE SCHOOL IN FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF SCIENCE (M.SC) IN SOIL SCIENCE, DELTA STATE UNIVERSITY, ABRAKA

DEPARTMENT OF AGRONOMY
DELTA STATE UNIVERSITY, ASABA CAMPUS

SUPERVISOR: DR. C. N. EGBUCHUA

SEPTEMBER, 2015

DECLARATION

I declare that this work is an original research work carried out by me in the Department of Agronomy

----

Young, Elohor
Student

CERTIFICATION

We certify that this work was carried out by Young Elohor of the Department of Agronomy, Delta State University, Asaba campus, Nigeria.

----------------------- --------------------

DR. C .N EGBUCHUA Date
Supervisor

------------------------ --------------------

PROF. I.M. OJEIFO Date
Head of Department

------------------------- ----------------------

External Examiner Date

DEDICATION

I dedicate this work to God Almighty, for the courage to carry on. Also to my parent Mr and Mrs Young Unuavworho.

ACKNOWLEDGEMENTS

Thanks to God for inspiration, enablement and perfection of this course. The determination fully came from God.

I want to say a special thank you to all my lecturers for both their encouragement and academic guidance. My hearty thanks go to Prof. I.M. Ojeifo (Head of Department), Prof. S.O. Emosairue, Prof. S.O. Akparobi, Prof. P.G. Eruotor, and Dr. C. N. Egbuchua (My dear Supervisor), Dr. F.N. Emuh, Dr. E.O. Egho, Dr. (Mrs). B.O. Bosah, Dr. F. O.Tobih, C.C. Obiazi, S.A. Ojobor, Dr. E.C. Enujeke and Prof. L.U. Okomah of the blessed memory.

I wish to also remember very special family members and friends for the various roles they played. First is Rtn Andy Uwejeyah for his financial support, my brothers and sisters, with a host of other family members, church members and friends for their continuous encouragement, prayer and concern, may the good Lord reward you all richly

Young, Elohor

TABLE OF CONTENTS

CHAPTER SIX

SUMMARY, CONCLUSION, RECOMMENDATION AND CONTRIBUTION TO KNOWLEDGE

ABSTRACT

Investigative soil survey was carried out in 2012/2014 cropping seasons in Delta state , Nigeria to evaluates the nutrients and nitrate nitrogen contents of the soils used for vegetable pr0dution. These four locations with the pedigree of extensive rainy and dry seasons vegetable productions were Oko-anala, Eke-mkpor, Orogodo plain and Ossissa flood plain.The research test crops which were selected based on the volume of demand in the localities were Fluted pumpkin (*Telfairia occidentallis*), *Amaranthus cruentus* (green leaf), and Okro (*Abelmoschuc esculentus*). Four farmer's farms were randomly selected from each of the areas and five samples of the individual vegetables also randomly selected for the purpose of wet ashing inorder to determined NO_3^-N uptake. From each of the farmer plots, core samples were also collected and bulk into composite sample for the determination of some physiochemical properties of the soils. The physiochemical properties evaluated were the particle size distribution, soil pH, organic matter, total nitrogen, available phosphorous, exchangeable bases, exchangeable acidity and Effective cation exchange capacity (ECEC). The chemical characteristics of the individual soils showed that pH of the soil were strongly acidic with a mean pH range of 4.3-5.8, organic matter content was low to moderate with a mean values of 0.70-0.84gkg^{-1} , total nitrogen was also low to moderate with mean value of 0.31- 0.58gkg^{-1} . Available phosphorous were low to moderate with a mean values of 6.90 and 8.51mgkg^{-1}.The exchangeable bases of Ca and mg, K were low to moderate. The Nitrate –nitrogen (NO_3-N) contents of the soils cultivated across and within horizons in the mapping unit ranged from0.25-0.47gkg^{-1} for *Telferia occidentalis*,0.28-0.56gkg^{-1} for *Amaranthus cruentus* and 0.12-0.48gkg^{-1} for *Abelmoschuc esculentus* Uptake of nitrate nitrogen from the proximate analysis in respect to individual farmer plot ranged from 0.03-0.07gkg^{-1} for *Telferia occidentalis* and 0.07-0.12gkg^{-1} for *Amaranthus cruentus* and 0.02-0.07gkg^{-1} for *Abelmoschus esculentus*. These value however depicts low nitrate nitrogen of the soil and low uptake which is within the international permissiable limit for healthy consumption of vegetable. The general results of the investigation showed that the soils were moderate in fertility and the contents of NO_3^-N was low and poses no threat to live. However, there is need for caution in the use of nitrogenous based fertilizers

CHAPTER ONE

INTRODUCTION

In every soil analysis for nutrient investigation, the basic soil physio-chemical properties evaluated include the particle size distribution, soil pH, organic carbon, total nitrogen, available phosphorous, exchangeable bases, cation exchange capacity, exchange acidity and base saturation.(Esu, 2004). These soil physiochemical properties are important soil parameters that largely determine the productive potentials of any given soil(Brady and Weil, 2007).

Nitrate(NO_3^-) and ammonium(NH_4) are the available forms of nitrogen in the soil, and the nitrate forms being more significant in terms of plant availability and abundance (Havlin *et al.*, 2005). The accumulation of nitrate is very common in vegetable crop production system. This is because such system is usually fertilized with heavy doses of nitrogenous fertilizer in the forms of ammonium sulphate (NH_4SO_4), ammonium nitrate (NH_4NO_3) or Urea ($CO(NH_2)_2$) in order to promote vegetative growth (Havin et *al.*, 2005, Brady and Weil, 2007). Majority of plant available nitrogen is in the organic form of nitrate (NO_3) and ammonium (NH_4) and are assimilated so fastly to the extent that there concentration within plant tissues never get to critical level (Eckert, 2008). High nitrate-N accumulation in the soil which arise as a result of over application of nitrogenous fertilizers can cause numerous problems such as low nitrogen use efficiency, environmental contamination through leaching of nitrate-nitrogen to ground water thereby causing eutrophication (Brady and Weil, 2007, Hong et al., 2007 and cui *et al*, 2008).

Eckert (2008) has also reported that nitrate content in the soil that is greater than 10 mg in drinking water either in domestic wells, streams, lakes could cause a potential fatal disease such as methoemoglobinamia in children and prostrate cancer in adult. Nitrogen is negatively charged and as such, it does not bind to the soil solution.and this makes it easily leached from the upper soil horizon down to the rooting zones by rain or by irrigation water; (Wild, 1988, Brady and Weil, 2007). The importance of vegetable in the diet of people especially in the Sub-Saharan Africa cannot be under-estimated. During the Nigeria Civil War (1967-1970) Obiakor (1971) reported emphatically, that what saved millions of children from iminent death emancipating from the the Biafra side due to nutrient deficiencies were vegetable crops According to Ogunlesi *et al* (2010), the consumption of vegetables were reported to protect the human body from degenerative diseases, which has been attributed to the anti-oxidant that is present in them.

Condes *et al., (*2009), Tironi and Anon (2010), have reported that vegetables are very high in Vitamin C, while those that are leguminous have high content of protein 3 – 6 and up to 4-6 g, 150-410 m/g^{-1} of calcium, 2.9-8.1m/g^{-1} iron, 5.7-6.5 m/g^{-1} of beta carotene. All these are health improving vitamin sources and are richly contained in vegetable crops. In most tropical environment the growing of vegetables are cultivated both in dry and rainy seasons of the year and more extensively in the hydromorphic or alluvial soils. Hydromorphic or alluvial soils are soil with perched water table that are seasonally flooded. When the flood recedes, the moisture content of the soils are usually high and thus, can sustain vegetable production for about three months in the drier parts of the year. In recent years, because of the economic situation and high levels of unemployment in the Nigeria, many people are now involved in large scale vegetables production as a source of livelihood Their main soil media for sustainable production have been the hydromorphic or alluvial soils. These soils are extensively cultivated in the dry season. The hydromorphic soils that are essentially utilized for these purpose can be classified either as hydromorphism, in which the soil material are subjected to short period of saturation and show little or no mobility of iron. The moderate hydromorphism are soil that are saturated in several consecutive days and show clear mobility of iron. The strong hydromorphism on the other hand, are soil material that remains completely wet during several months. The strong hydromorphism however is not essentially used for vegetable production (Stoop and Eswaran, 1984).

Because of the leafy aspects of vegetables for various food consumption, medicinal purposes, pharmaceutical needs and as livestock feeds ,the growing of vegetables have been intensified in scope with the use of mineral fertilizers especially nitrogenous fertilizers. The use undermines the fact that heavy fertilization (N – fertilizers) could exceed what plant are able to utilize and thus a major source of excessive nitrate leaching. (Havlin et al, 2005) On the other hand, excessive intake of nitrate by cultivated plants could be detrimental to human (FAO, 2000). It is against this background that the objectives of this studies are:

1. To determine the nitrate nitrogen content of the alluvial soils used in large scale vegetable production.

2. To determine the physical and chemical properties of the soil as it relate to vegetable production.
3. To carry out proximate analysis of the vegetables that are grown in these soils in order to determine the absorbed nitrate content, if they are within the international permissible level for consumption

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition of Concept

Hydromorphic or alluvial soils are soils that occur over impervious shale and seasonal water logging is frequent (Enweazor *et al.*, 1990). They can also be defined as soils that are seasonally water logged, and most often found along the banks of major rivers and streams across the continent. In Soils Science the word Hydromorphic infers that the soil has features due to poor drainage and may have been developed in depressional, valleys, or flood plain (Akamigbo, 2001).

Egbuchua (2011), defined hydromorphic soil as intrazonal soils whose developments are strongly influenced by temporary water saturation especially in the upper part of the pedon. They are also soils that are found in association with all zonal soil where water can gather in sufficient volume and for sufficient time to produce the effect of gleying. It has also been linked to soil that are formed in terraces that are flat flooded and of low relief relative to the surrounding topography. Such soil include inland basin,coastal plain, and alluvial flood plains (Egbuchua, 2011).

2.2 Expression Of Different Degree of Hydromorphic Soils

Due to the controversy that are associated in differentiating soilS. Stoops and Eswaran (1985) came up with classical expression of hydromorphism as;Weak hydromorphis;, which are soils that are subject only to short period of saturation with little or no mobility of iron (fe).Moderate hydromorphism these soil materials saturated that are several consecutive day,with clear clear mobility of the iron present.

Strong hydromorphism: These are soils that remain completely wet or waterlogged for a longer period of time. In stongly hydromorphic soils,many plant remains are usually preserved in the soil material, and the horizons lack the well developed distinct boundaries.

2.3 Occurrence of hydromorphic soil

According to Akamigbo (2001) most hydromorphic soil are naturally occurring in terraces that are flat floored such as inland basin, valley bottom, coastal and alluvial plains.On the other hand, man made hydromorphic soil may developed on a flat land provided that the terraces are supplied with excessive water which may be caused by rainfall, lateral seepage flow, flooding excessive or high ground water table.

Kyuma (1995), opined that the occurrence of hydromorphic soil are guided by two controlled factor namely, physiography and climate.

The physiographic aspect has to do with the land drainage capacity as found in most depressional places such as the inland valley, tidal flats and coastal valley and in most cases adjacent to major river streams.Climate aspect has to do with environments that are associated with heavy concentration of rainfall that can cause flooding and water saturation in some part of the year.

Okusami and Rust (1992) stated that hydromorphic soils are associated with three land form types. These are inland depression, alluvial plains and coastal plains. All the land forms are located along major rivers and they are characteristically seasonally flooded and used extensively for dry season farming.

2.4 Fundamental characteristics

2.4.1 **Morphology**: Most hydromorphic soils have poorly drained profiles especially during the period of saturation. Thus, they are dominated by mottling, dark grey colours and peaty accumulation (Akamigbo, 2001, Egbuchua, 2011). Stoops and Eswaran reported that during the short period of water saturation in hydromorphic soil there is little or no mobility of iron and thus the high chroma of the matrix is preserved. Manganese is more readily reduced than Fe and can be translocated to the ped surface where it is precipitated as Mn coating and hypocoating.

On the other hand,there is usually reduction of Fe and Mn compound that give rise to low chroma inside the soil peds as in moderate hydromorphism. In strong hydromorphism in which the soil matrix remain completely wet during several month of the year most of Fe and Mn are removed from the soil profile and thus low chroma are therefore observed.

2.4.2 Physical characteristics

Brinkman and Blokhuis (1986), Akamigbo (2001) and Egbuchua (2011) in their respective studies of hydromorphicl soils stated that the physical property of most hydromorphic soil is extremely variable. These range from soft, semi-liquid, massive and structureless or laminated in perennially submerged condition to consolidated, firm with a blocky or prismatic structure, in seasonally flooded soils.Soils profiles range from underdeveloped to strongly developed.The particle size distributions are known to be dominated by clay and silt fraction that are filled by fine sand with no clear arrangement in the matrix of particle size classes of these soil.

2.4.3 Chemical characteristics

Just like the physical characteristics, the chemical characteristics of most hydromorphic soils are known to vary; These variations could be as a result to cropping history, management factor as well as physiography of the soil.(Egbuchua,2007) Generally, the pH of most hydromorphic soil varies from strongly acidic to moderately acidic (5.1 – 5.5 and 5.6 – 6.0). Akamigbo *et al,* (2001), Raji et al.,(2001) and Egbuchua, (2011) respectively. The organic matter context varies from low to moderate and is known to decrease with increase in soil depth. Total nitrogen also varies from low to moderate and are known to decrease with increase in soil depth. Total nitrogen also varies from low to moderate depending on the organic status of the soil.

Enwezor *et al,* (1990), Egbuchua ,(2007),stated that the phosphorus content of most hydromorphic soil could vary from low to moderate According to Akamigbo *et al,* (2001) the reason of low phosphate value of most hydromorphic soil could be ascribed to low phosphate potential of the parent soil and high fixation rate of the phosphate iron in the soil. On the other hand, Egbuchua,(2011) attributed low available phosphorus status to either as a result of high p-soption capacity of the soil or by a low absolute content of phosphorus in the soil.Sanchez (1976) in his well articulated book On Properties And Management of Tropical Soil listed six (6) causes of general increase in P-availability upon soil submergence to include reduction of iron-phosphorus, dissolution of occluded phosphorous, hydrolysis of Fe and Aluminuim to Phosphorous in acid soils, increased solubility of calcium to phosphorous in calcerous soils and greater diffusion phosphorous. Lekwa *et al.,* (2001), Ufot *et al.,(* 2001), Udo, (2001) have all reported varied status of nutrient from low to moderate in terms of basic cation such as Ca, Mg, K, Na and cation exchange capacity in hydromorphic soil. The moderate status of basic cation has been attributed to alluvia deposits during flooding regime. On the other hand, the low status has also been ascribed to extensive use of the soil without replenishing the loss nutrient through organic residue amendment and application of synthetic fertilizers as well as liming to reduce soil acidity.

2.5 Classification of Hydromorphic Soil

Many soil classification of hydromorphic soil have either similar or different taxonomic name. The systems whether they are natural or artificial or recognized the peculiar characteristics imparted to the soil by hydromorphism (Akamigbo, 2001). The zonality concept which many of this system have applied recognized hydromorphic sites as transitional or intra-zonal or “Azonal”. This is because of the hydromorphic and halomorphic conditions under which soils developed. The French system recognizes these concepts and classifies these soils at the highest level of generalization.The 1964 CCTV soil map of Africa classification recognize soils influenced by hydromorphism at the highest class level. The soil taxonomy Soil Taxonomy Soil Survey, (1975) does not recognize the influence of wetness at the highest categorical level but uses the aquic moisture regime and specified morphologic characteristics of wetness to distinguish such soil at the sub order level. However, aquic subgroups generally are not hydromorphic soil but have signs of wetness only in lower horizon (Brinkman and Blokuis, 1986). Other soil order that may show hydromorphic include mollisols, Alfisols, entisols, Inceptisol, Oxisols, Spodosols, Ultisols and Vertisols.There hydromorphic setting however depend on their physiography.

The European classification system generally distinguishes two main kinds of wetland soil with different hydrologic condition at the highest categorical level: ground water gley or true gley and surface water gley (or pseudo gley) soils. The ORTSOM classification relegates the hydrmorphic soils to group and subgroup levesl where they are recognized on the basis of gley or hemigley horizon within specified depths below the A-horizon. Gley and hemigley horizons are grey to bluish grey distinguished by the presence of yellow, brown or red mottles and the simultaneous presence of iron in reduced and oxidized forms.In general most hydromorphic soil that are associated with annual flooding have varied wetness, profile differentiation they can be classified as fluvaquent, argialbolls, ochraquent and tropaqualf. In summary, inceptisol, entisols, alfisols, ultisols makeup the greatest number while mollisols and histosols are very scanty and mostly associated with soils of strong hydromorphism.

2.6 Potential uses of hydromorphic soil

According to Vink (1975) land use is defined as any kind of permanent or cyclic human intervention to satisfy human needs from a complex of natural and artificial resources which together constitute land.

Odingo (1991) on the other hand reported that land use in Africa is excessively influenced by the existing ecological condition and is in turn influenced by the patterns of use which have been set by previous generation and administrations depending on the kind and level of teaching which was available to them at the time. The hydromorphic soil are regarded as very fertile soil in the arid and semi-arid area of the World and as such, they are extensively/utilized in arable farming especially during dry season farming. For the fact that the soil contains high level of soil moisture (residual moisture) during the dry season as, well as during draught period, the soil is very important for agricultural activities throughout the year and therefore makes farming a continous process (Yakubu *et al.,* 2004).

In most arid and semi-arid environment, the hydromoprhic soil are regarded as the `locc`i of agriculture. This is because all agricultural activities (crop production) take place in the soil. Because the soils have a high texture with reasonably good hydraulic property it therefore presents farmers a range of soil resource option suitable for a host of agronomics and horticultural crop production (Yakubu et al,2004).

In most part of the World, the hydromorphic soils are the major rice producing soils; this is because of their hydrological characteristics particularly the flooding regime. The major crops that are grown in these soils include Rice, Sugar, cane, Water leaf, fluted pumpkin, Garden egg, Okra, Pepper, Maize, and a lot of pulses and cereals .

Young (1976), acknowledged that by far the most extensive soil use for paddy rice production are the alluvial soil hydromorphic soil. In recent years many government in the Sub-Saharan Africa are intensively developing their hydromorphic soils to mitigate food security challenges especially in the area of crop production.

2.7 Problem associated with hydromorphic soil

According to Vanmensvoort *et al.,* (1986), soil salinity is a problem in most hydromorphic soils with sea water intrusions especially in the coastal area and inland valleys. Iron toxicity which affect acid sandy soils and acid sulphate soils has also been identified as problems of the soil reported. Aluminum toxicity especially in sandy soils of hydromorphic nature is probably the most serious toxicity of hydromorphic soils. The most physical problem associated with these soils are the problems of excessive flooding, during flooding regime for example in Nigeria in 2012 virtually all the hydromorphic soil areas were completely submerged thereby causing a serious threat to food security agenda of the government. Another problem is excessive leaching especially nitrate_nitrogen ions which compound the nitrogen availability of the soils.

2.8 Vegetable Production in Hydromorphic Soil

Hydromorphic soils are natural ecological environment that are seasonally flooded. During the flooding regime at the peak of rainy season, the soil environment is usually submerged and thus they become saturated with water. However in the drier part of the year as flood recedes, the soil contains high level of soil moisture (residual moisture) that can sustain vegetable production until the next rainy season. During these dry periods, dry season vegetables production takes place in the soil (Eshett, 1993). The prominent vegetables mostly annual crop ones that are extensively cultivated include

Amaranthus (green leaf), *Telfairia* (pumpkin), Okra, Water leaf, Witter leaf, Shoko, pepper, Lettuce and a wide species of pulses and legumes. The production of these vegetables are made possible because of the seasonal flooding of the soil environment which when recedes provides the soil environment with great the soil environment moisture regime and nutrient content that can sustain vegetable production for at least four month preceding the next rainy season (Wilding and Rehage, 1986).

2.9 Morphological Characteristics Of The Test Crops

2.9.1 *Telfairia occidentalis(Fluted pumpkin)*

Fluted pumpkin (*Telfairia occidentalis*) belongs to the gourd family of cucurbitaceae. It comprises of leaves, fruits, vine, stem, tendrils and seeds. It grows as a coarse trailing vine with broad prickly leaves and large yellow or orange colour fruits. Fluted pumpkin (*Telfairia occidentalis*) is recognized for its importance as a vegetable due to its protein content which is as much as 13% in the seed and its abundance in essential nutrient for human and as animal feed. It has very low commercial value as an oil seed. The crop is grown mainly for the leaves which constitute an important component in the diets of many West Africa Countries. The fruits contain seeds that can be boiled and eaten or grind into powder four soup (Agusiobo, 2001).

Fluted pumpkin as a leafy vegetable provide a rich source of vitamin, mineral oil, crude fibre, protein and other chemical substances often called protective food due to their function in preventing disease in human body. Fluted pumpkin is important in neutralizing the acid produce during the digestion of meats, cheese and other fats, and they are used as regulators in the digestive tract system. They are also used as appetizers, soups and main dishes. The pulp and pod is used as livestock feed after fermentation and as a source of organic fertilizer for soil enrichment The crop is a common vegetable delicacies in Delta State and the demand for it is high.

2.9.2 *Abelmoschuc Esculentus(Okra)*

These plants (okra) is a herbaceous annual, with a stem somewhat woody at the base, attaining a height of 3-6 feet and being 3 or 4 inches thick bearing alternate, serrated leaves of 3 varieties angular, palmate and sub-digitae. The okra fruit is a pentagonal narrow, cylindrical capsule from 2 to 12 inches long; tapering at the base and about 1 inch in diameter. It is often curved and is covered with hairs, especially along the ridges. The pod contains several roundish or kidney shaped smooth seeds in each of the several cells (Vegetable research, 2000).

Kirky (1993) reported that the tender fruit of okra are used as vegetable either boiled or sliced and fried. They have high mucilage content and are used in soups and gravies. They are one of the ingredients of callaloo soup, a Trinidian dish. The ripe seeds contain about 20 percent of an edible oil. According to Kirby (1993) a mucilaginous preparation from the pod can be used as plasma replacement or blood volume expander. Mucilage from the stem and roots is used for clarifying sugar cane juice in gum manufacture in India and for sizzling paper in China. Grubben (1977) has identified okra as a very important vegetable food item in human nutrition, supplying minerals, vitamins, certain types of hormone precursors in addition to protein and energy. The important of okra a vegetable lies in the "drawing" or mucilaginous properties of the fruit, which aid in the easy consumption of bulky staple food like garri, cassava, pounded yam. Okra is produced mainly for local domestic use yet it is of economic importance, especially when grown off season as a sole crop. People who prefer a more solid and less glutinous okra texture can add lemon juice to the dish he concluded.

2.9.3 *Amaranthus cruentus*

Amaranthus cruentus is a flowering plant species that yields the nutritious staple amarath grain. It is a tall annual herb topped with clusters of dark pink flowers. The plant can grow up to 2m (6ft) in height, and blooms in summer to fall. It is believed to have originated from Amaranthus hybridus, which share many morphological features. The plant is usually green in color, but a purple variant was once grown for the use in inca rituals. (Grubben et al),2004.

Amaranthus cruentus is use as a food source, the seed are eaten as cereal grain. The grain are ground into flour, popped like pop corn, cooked into porridge and made into confectionary called alegria. The leaves can be cooked like spinach, and the seeds can be germinated into nutritious sprouts. Among the zuni people, the feathering part of plant ground into a fine meal and use to color ceremonial bread red, Stevenson, 1915. The crushed leaves and blossoms are also moistened and rubbed on cheeks as rouge,(Stevenson,1915).

2.10 Nitrate perspective

Nitrate is a polyatomic ion with the molecular formula $N0_3^-$ and a molecule mass of 62.004g/mol. Nitrate also describe the organic functional group $RONO_2$. These nitrate esters are specialized class of explosives. Nitrate toxicosis can occur through enterohepatic metabolism of nitrate due to nitrite being an intermediate (Merck,2008). Nitrite oxidize the iron atoms in hemoglobin from ferrous iron (2^{+}) to ferric iron (3^{+}) rendering it unable to carry oxygen. The process can lead to general lack of oxygen in organ, tissue and a dangerous condition called methemogblobinemia. Although nitrite convert to ammonia, if there is more nitrite than can be converted, the animal slowly suffer from lack of oxygen, Stoltenow et al, (2008).

Human are subject to nitrate toxicity, with infant being especially vulnerable to methemoglobinemia due to nitrate metabolizing triglyceride present at higher concentrations that at other stages of development. Methemoglobinemia in infant is known as blue baby syndrome. Although nitrate in drinking water were once thought to be contributing factor, however nitrate exposure may also occur if eating for instance, vegetables containing high level of nitrate.(Marschner,1999).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the study area

The study was conducted in four locations with hydromorphic soil origin that are known for large scale vegetable production. The locations were identified through reconnaissance soil survey method that showed the hydromorphic characteristics and their sustainability for large scale vegetable production. On the basis of this and through personal interviews on vegetable production, the following places were identified; oko-anala (6° 06` N and longitude 6° N2`E) in Oshimili South Local Government Area; the inland valleys of Orogodo River in Agbor along Agbor-Benin express road which lies within (latitude 5° 43`N and longitude 6° 20 `E);Eke Nkpo which is a camp village located at the depressional soil by the right hand side of Delta State University Teaching and Research Farm close to the bank of River Niger (6°`N and longitude 6° 49`E) of the equator and hydromorphic soil of Ossissa which covers a large scale of inland plain and located within latitude (5° 40`N and longitude 6° 10`E). These locations lie within the rainforest transitional ecological zone that are characterized by mean annual rainfall of 1550mm – 2000mm, a relative humidity of 65 -75% and temperature of 33-37.4°C (Ministry of Avaition Asaba, 2012). The rainfall distribution is bi-modal in nature with peaks usually experienced between July and September and frequently punctuated by a short dry spell in August otherwise known as ‘August break’. In recent years, the so-called ‘August break’ has been affected by climate change which invariable make the observation of August break as a thing of the past.

The geology of these areas are formed on fresh water alluvium and are hydromorphic soil found either in inland valley or flood plains (Egbuchua, 2007). According to the classifications of Enwezor *et al.,* (1988) and Akamigbo, (2001), the soils belong to the Alfisols and Ultisols Order and individually classified as "Typic Tropaqualf, aquic haplustalf and aquic kandiustults and psammatic paleudults" (USDA,1994). The vegetation of the study areas are mainly of rainforest species The land use characteristic is basically on rainfed agriculture and extensively used for wide varieties of vegetables cultivation during the dry season. An isohyperthermie and udic moisture regime typified the general environment of the study areas.

3.2 Field Work

The field work was preceded by two activities. The first activity involved soil sampling and sample preparation for the analysis of the physico-chemical properties of the soils and their nitrate nitrogen contents. The second activity involved leaf sampling of the test crops for the purpose of evaluating nitrate-nitrogen uptake by the crops.

3.2.1 Field mapping

In each of the location two transcent were mapped across the field and four spot marked out at a distance of 3-5m each. Surface and subsurface soil depths(0-15cm, 15-30cm) were established and designated as A and B with the following possible combination: A_2, B_2, A_3, B_3, A_4, B_4, A_5, B_5, A_6, B_6, A_7, B_7, and A_8, B_8, for the first transcent and second transcent respectively.

3.2.2 Soil Sampling and Sample Preparation

Soil samples were randomly collected using a short spade to excavate the soils. The excavated soils were carefully packed into polythene bags. The samples were air dried at room temperature of, crushed, grinded and seieved to pass through a 2mm sieve mesh and carefully packed in a well labeled mini envelopes for laboratory analysis.

3.3 Selection of Test Crops

Based on recognaissance survey of vegetables that have the greatest demand and consumption rates in the environment,*Telfairia occidentalis* popularly (fluted pumpkin), *Amaranthus cruentus* (Green vegetable) and *Abelmoschuc esculentus*(Okra) were selected. Four farmers farms were chosen from each of the location and sample vegetables were randomly collected from each of the farmers plot. For each vegetable type,five(5) plant samples were collected by cutting from the base.

3.4.1 Experimental Procedures

Particle Size Distribution

This was done using Bouyoucous hydrometer method(Bouyoucous, 1951). Where about 50g of soil was weighed into a 500ml dispensing cup and about 200ml of distilled water added to the dispersing cup.Then after 20 ml of 0.5N sodium hexametaphosphate

(Calgon) which is a dispersing solution was added and the soil allowed to soak for about 15mins before dispersion.it was stirred for 10 mins in an electric shaker. Then it was made up to 1000ml mark with distilled water and the content was vigorously shaken by placing the palm of one hand over the mouth of the cylinder. After about half a minute, the hydrometer was slowly and carefully placed in the suspension and at exactly one minute the first hydrometer reading was taken at the top of the meniscus. To determine the temperature, the soil thermometer was placed in and out and the suspension was left for two hours after which, another, hydrometer reading was taken.

The hydrometer reading was corrected by adding 0.3 for every degree centigrade that the temperature is above the calibration temperature, or by subtracting 0.3 for every degree that the temperature is below the calibration temperature.

The % Silt + Clay was calculated as:

$$\text{Silt} = \frac{\text{Corrected 1 – min reading}}{\text{Weight of sample}} \times \frac{100}{1}$$

$$\text{Clay} = \frac{\text{Corrected 2 hours hydrometer reading}}{\text{Weight of sample}} \times \frac{100}{1}$$

3.4.2 Soil pH(electrometric method)

About 5g of the soil was put in a 25 ml glass beaker, followed by the addition of 5ml of distilled water and was stirred with a glass rod. These was allowed to stand for about 15 minutes before it was stirred again and the pH electrode was carefully placed into the soil solution mixture and the pH reading taken.

3.4.3 Soil Organic Matter (Walkey-Black oxidation method)

About 25g of soil that has been made to pass through a 60 mesh sieve was weighed into a 500 ml, Erlenmeyer flask. Then, 10ml of $K_2Cr_2O_7$ pipette into the flask and swirled to mix thoroughly. Then, 200ml of Conc, H_2SO_4 was added into the mixture and swirled carefully and gently for minutes and allowed o stand for about 30 minutes. After this, the suspension was diluted with about 200ml of distilled water, after which,10ml of 85% H_3PO_4 and 0.2g of sodium flouride and 4 drops of phenonthaline indicator was added. This was followed by back titrating the excess $K_2Cr_2O_7$ with 0.25m ferrous solution to wine-red end point. A reagent blank was run following the same procedure but without any soil.

The organic of the soil was calculated as:

$$\frac{M_1FeSO_4 \text{ for black} - M_1FeSO_4 \text{ for sample}}{\text{Wt of Soil used}} \times \text{Conc } FeSO_4 = \text{Meq Ox/g}$$

% C = Meq Ox/g x 0.390

% OM = % C x 1.72

3.4.4 Total Nitrogen (Micro Kjeldahl Procedure)

10g of air dried soil sample was weighed into a filter paper in duplicates and the sample screwed up and put into a dry 500 ml kjeldahl flask. Then a tablet of selenium which acts as a catalyst was added. These was followed by the addition of 30 ml of Conc. H_2SO_4 the contents and thoroughly mixed by swirling. The mixture was heated in a fume cupboard by rotating the flask at intervals until clear digest (light green or grey colour) was obtained. The digest was then allowed to cool before 100 ml of tap water was added, shaken and transferred to a clean flask. Then after, 50ml of 4% boric acide was added into a 500 ml conical flask, on a marked 150 ml level, and 3 drops of methyl indicator added. The flask was placed in such a way that the tip of the condenser tube was below the surface of the boric acid. To the flask containing the diluted digest, a small piece of litmus paper was added and 125ml of 45% NaOH also gently and carefully added down the side of the flask so that the alkali will form a layer below the acid. The flask was later attached to a condenser with the contents thoroughly mixed and finally distilled until about 150 ml of the liquid are present in the receiving flask. The extract received was finally titrated with standard HCL (0.05N) to a grey-blue colour.

Calculation

The mg of N in the sample = Mi of HCL used (i.e. titrated value – blank x normality of HCL)

To convert to %N = We have to multiply by the factor 0.14.

3.4.5 Available phosphorus

5.0g of air dried soil samples was weighed into a conical flask, and 30 ml of extracting solution added and subsequently shaken for one minute. This was then filtered immediately through a Whatman No 42 filter paper.The aliquot of the extract was placed in a labeled test-tube and a molybdenum blue colour developed by first of all dissolving 12g of ammonium molydate into 250 ml of distilled water and also dissolving 0.29g of antimony potassium titrate. Both reagent were later added to 1000 ml of $5NH_2SO_4$ (148 ml Conc H_2SO_4 to 1 litre) and mixed thoroughly and finally made up to 2,000 ml.The standard curve that has been prepared is then used to read off the concentrate of phosphorus in the coloured solution

3.4.6 Determination of Basic Cation (EDTA Titration)

Before the determination was started, a reference end-point was obtained by mixing ml of 1M NaOH with 5 drops of calgon and made to mark by diluting with 100 ml of distilled water, and then titrating with EDTA-solution.(Ethyln Diamimetetra acetic)

Again, 5ml of the sample extract was weighed into a flask. This was followed by adding 100 ml of H_2O, 5 ml of 1M NaOH and 5 drops of Phenonythaline indicator. This was further titrated with EDTA to end point that is the same with the reference end point. Blank titration was also done and this was subtracted from the sample reading.

Calcium in the extract was calculated as:

$$Ca\ (cmolkg^{-1}) = \frac{Xml \times volume\ of\ solution}{10 \times Aliquout \times sample\ wt}$$

3.4.7 Determination of Magnesium

About 5ml of the aliquot was pipette into a 50 ml beaker which was diluted to 50 ml. This was followed by the addition of 10 ml of NaOH solution and 15 ml of buffer solution.Thereafter, it was heated slowly for 15 minutes and later filtered using No 42 filter paper into a titration flask. This again followed by adding 10 drops of Eriochoma black T indicator and 2 ml triethanolamine. The aliquot was finally titrated with EDTA to a clear blue end point.

$$\text{Mg (cmolkg}^{-1}) = \frac{\text{X ml x volume of solution}}{\text{10 x aliquot x weight of sample}}$$

3.4.8 Exchangeable Acidity

This is the portion of CEC that is taken up by H^+ and Al^{3t}. Exchangeable acidity was determined by this procedure below:-

About 10g of the sieved soil sample was weighed into 125 ml Erlenmeyer flask and 25 ml of 1N kcl added. The contents were mixed thoroughly and allowed to stand for 30 minutes. 25 ml of the contents was transferred into a 250 ml flask and made up to 150 ml. This was followed by adding, 4 drops of phenopthaline solution and titrated with 0.1 NaOH to a pink end point. A blank titrate of the solution was done by titrating 150 ml of 1NKCL with 0.1N NaOH using phenopthaline as the indicator.

The total exchangeable acidity of the soil was calculated

Sample titre value = X_1 (ml)

Blank titre value = X_2 (ml)

Wt of sample = Y(g)

$$\text{Exchangeable Acidity(cmolkg}^{-1}) = \frac{X^1 - X^2 \text{ N}10^2}{\text{Y (Sample weight)}}$$

Where N is the normality of NaOH.

3.4.9 Cation Exchange Capacity (Neutral Ammonium Acetate Displacement Method)

5g of air dried soil sample was weighed into 125 ml Erlenmayer flask and 30 ml of potassium acetate solution added. The Erlenmeyer flask was covered tightly with the rubber stopper and shaken thoroughly for one hour on a mechanical shaker. After shaking, the suspension was immediately transferred into a centrifuge tube and later leached with 60 ml potassium acetate. After the laechate has been removed, the exchangeable potassium in the sample was determined by leaching with 20 ml portion of 1N NH_4OAC solution then determine the potassium on a Flame photometer.

For CEC, it was titrate with 0.05 N EDTA until the colour of the solution changed from red-orange to grey.

The CEC is thus calculated as below:

$$CEC\ (cmolkg^{-1}) = \frac{\text{Ml of EDTA x N x } 10^2}{\text{Oven dry sample}}$$

Where N is the normality of the EDTA

3.4.10 Percentage Base Saturation

This was calculated as the sum of all base forming cation over CEC, multiply by 100%

$$\%BS = \frac{\text{Sum of all base forming cation}}{\text{CEC}} \times \frac{100}{1}$$

3.5 Nitrate nitrogen determination

The procedures for the determination of the nitrate nitrogen content of the soils were as follows:

Step 1: 2 grams of the prepared soil sample was weighed into a micro- kjeldahl distillation flask and 10ml of 2mkcl as well as 0.1g of MgO added to it. The flask was connected to distillation. Before the connection was done, 1 ml of sulphanic acid was added to the soil sample to destroy nitrite - nitrate (NO_2N).

Step 2: 0.2g of Devarda alloy was added to the soil sample using a long steam funnel. The purpose of the devarde alloy was to reduce the nitrate and nitrite, nitrogen to ammonium nitrate.

Step 3: The distillation flask was further re-attached to the distillation apparatus and distillation started by closing the stop cork of the steamer pass tube of the distillation apparatus.

Step 4: When the distillate has reached 30 ml mark. It was stopped and the end of the condenser rinsed.

Step 5: The distillate was finally titrated with $0.005NH_2SO_4$ from micro-burnette. The end point was reached when a colour change occur from green to a permanent faint pink.

3.6 Plant Tissue Analysis(proximate Analysis)

Plant tissue analysed was done in order to evaluate nitrate uptake of the various vegetables under study. The procedure used was that of Agbenin (1995).This involves wet ashing which is the decomposition of plant material in a mixture of three (3) strong acids namely Nitric acid, Sulphuric and Perchloric acid. The steps involved are outlined as below:

Step 1: 1 gram of the finely grinded plant materials (test crops) was weighed into a porcelain crucible. The crucible was then put into a muffle furnace at a temperature of 500°C at least for a period of 2 hours for Complete ashing which was noticed when the grey colour of the distillate appeared.

Step 2: The distillated (ignited sample) was moisted with distilled water and 5 ml of ammonium chloride added in order to slowly dissolved the nitrate content.

Step 3: The distillate was filtered through a whatman No. 40 filter paper into a 100 ml volumetric flask and the flask diluted to mark with distilled water.

Step 4: The nitrate nitrogen (NO_3^- N) content was finally determined by B and 1 spectronic 70 electrophotometer methods The research was done at the international Institute of tropical agriculture standard laboratory.

3.7 Data Analysis

The data collected were subjected to descriptive statistics and analysis of variance (ANOVA) to compare the four locations, were significant means were separated using, Duncan multiple range test.(DMRT).

CHAPTER FOUR

RESULTS

Particle size distribution

The results of the particle size distributions of the study areas are presented in Tables 1-4 respectively.

4.1 Oko-Anala mapping unit

The Particle size distribution showed that sand was the dominant soil fraction with a mean value of 67.91% and a coefficient of variation of 4.15%. Sand fraction was found to decrease with profile depth in the various horizon. Silt was relatively low with a mean value of 7.44% and a coefficient of variation of 12.60%.which is least variable There was no definite pattern of distribution of silt across the individual soil units studied. Clay on the other hand, was moderate with a mean value of 24.55% and a coefficient of variation of 15.4%.which is moderately variable

Generally across the mapping unit the silt content was found to increase with increasing depth of profile. The silt/clay ratio varied within horizon and ranged from 0.21-0.42 with a mean of 0.31% and a coefficient of variation of 29% which is moderately variable. The textural class for the mapping unit based o the USDA textural triangle showed that it varied from sandy clay loam to sandy loam

4.2 Eke Nkpor Mapping unit

The Particle size distribution of the mapping unit showed remarkable variability across and within horizons. Sand was the dominant soil fraction with a ranged value from 61.70-

79.45%, with a mean value of 70.23% and a coefficient of variation of 9.4%which is least variable. Across the soil unit the pattern of distribution was irregular without any defined trend. The content of silt was also low to moderate with a range of 4.80 – 11.00%, mean value of 6.01% and 30.90% coefficient of variation which is moderately variable. The total silt content however was in most cases, found to decrease with depth of soil profile. The clay content on the other hand ranged from 15.35-28.50% with mean of 23.75% and coefficient of variation of 26.89% which is least variable.

Unlike mapping unit A, the clay contents of the mapping unit did not follow any pattern of distribution, but however tended to increase with depth in mapping unit A and C but decreased correspondingly in mapping unit B and D respectively (Table 2). The silt/clay ratio also varied across horizons in the mapping units, it ranged from 0.19-0.40 with a mean value 0.26% and coefficient of variation 34.60% which is highly variable. Texturally the soil of the mapping unit varied from sandy clay loam to sandy loam and loamy sand respectively.(Table 2)

4.3 Orogodo-River Mapping Unit

The sand fraction was most dominant across the horizons with a ranged value of 70.0 – 87.25% , mean value of 84.08% and coefficient of variation of 7.4% which is least variable. The total sand content also was irregularly distributed. Silt on the other hand was generally low with a range of 3.50 – 8.10% a mean of 5.13%, and coefficient of variations of 29.20% depicting moderately variable. The clay content of the mapping unit however had a mean value of 10.65% and a coefficient of variation of 48.10% which is highly variable. The texture of the mapping unit ranged from dominantly sandy loam both at surface and subsurface horizon to loamy sand, respectively. (Table 3)

4.4 Ossissa Mapping Unit

The Particle size distribution in the mapping unit showed that sand fraction ranged from 75.35 – 92.15% with a mean value of 89.65% and a coefficient of variation of 6.60% which is least variable. The content of total sand in this tend to decrease with soil depth with more content at the upper horizons than the lower horizon. Silt fraction on the other hand, was fairly distributed. The value ranged from 3.10 – 8.15% with a mean of 4.91% and a coefficient of variation of 32.60% which is moderately variable. The clay contents unlike the sand fraction was found to increase with depth. The contents of clay was relatively low with a range value of 3.0 – 16.50%, a mean value of 6.03% and a coefficient of variation of 74.60% which is highly variable. The silt/clay ratio varied across the horizons with a range value of 0.49 – 1.60% a mean of 0.98% and a coefficient of variation of 39.80% which is highly variable. In most cases, the silt/clay ratio were more definite in distribution and was found to increase with depth of profile. The texture according to the USDA textural triangle varied from dominant sand at the surface horizon, loamy sand and sandy loam at the subsurface horizon

Table 1: Particle size distribution of soil Oko-anala in Oshimili South Local Government Area, Delta State.

Location	Soil Depth (cm)	Coarse Sand	Fine Sand	Total sand (%)	Silt	Clay	Silt/clay ratio	Textural class
A	0-15	53.45	11.75	65.20	6.20	28.32	0.22	SCL
	15-30	53.35	11.85	65.20	6.45	28.35	0.23	SCL
B	0-15	54.25	11.70	65.95	7.25	26.80	0.27	SCL
	15-30	54.17[a]	11.95	66.12	7.20	26.68	0.26	SCL
C	0-15	45.17	25.15	70.30	8.75	20.93	0.42	SL
	15-30	44.95	26.10	71.25	8.35	20.60	0.41	SL
D	0-15	47.20	24.75	71.95	7.85	20.20	0.38	SL
	15-30	46.50	24.15	70.65	7.45	21.90	0.40	SL
Mean		**50.36**	**17.60**	**67.90**	**7.44**	**24.55**	**0.31**	
SD		**7.23**	**3.02**	**0.94**	**3.78**	**24.55**	**0.31**	
C.V%		**8.70**	**41.10**	**4.50**	**12.60**	**15.40**	**29.00**	

Abbreviation: SCL=Sandy clay loam,SL=Sandy loam,Sd=Standard deviation,CV=Coefficient of variation

Table 2: Particle size distribution of soil Eke-Nkpor-Anwai in Oshimili North Local Government Area, Delta State.

Location	Soil Depth (cm)	Coarse Sand	Fine Sand	Total sand (%)	Silt	Clay	Silt/clay ratio	Textural class
A	0-15	49.40	21.60	71.0	4.80	24.20	0.20	SCL
	15-30	48.38	20.55	68.93	4.85	26.12	0.20	SCL
B	0-15	46.55	19.45	66.00	5.50	28.50	0.19	SCL
	15-30	46.50	19.65	66.15	5.55	28.30	0.19	SCL
C	0-15	58.75	20.70	79.45	5.20	15.35	0.34	SL
	15-30	57.85	20.55	78.40	5.15	16.45	0.31	SL
D	0-15	36.35	25.35	61.70	11.0	27.30	0.40	LS
	15-30	36.25	28.20	64.45	10.35	25.20	0.40	LS
Mean		**49.11**	**21.12**	**70.23**	**6.01**	**23.75**	**0.26**	
SD		**7.60**	**1.99**	**6.60**	**2.22**	**5.56**	**0.09**	
CV%		**15.50**	**9.42**	**9.40**	**36.90**	**23.40**	**34.60**	

Abbreviations:SCL=Sandy clay loam,SL=Sandy loam,LS=Loam sand.SD=Standard deviation,CV=Coefficient of variation

Table 3: Particle size distribution of soil Orogodo in Agbor, Ika South Local Government Area of Delta State

Location	Soil Depth (cm)	Coarse Sand	Fine Sand	Total sand (%)	Silt	Clay	Silt/clay ratio	Textural class
A	0-15	75.0	10.50	85.50	3.50	10.00	0.35	SL
	15-30	75.0	10.75	85.75	3.75	10.50	0.36	SL
B	0-15	76.50	10.20	86.55	5.20	8.25	0.63	SL
	15-30	76.15	10.35	86.50	5.75	7.75	0.74	SL
C	0-15	76.50	10.75	87.25	4.85	7.90	0.61	SL
	15-30	76.15	10.85	87.00	4.85	8.15	0.60	SL
D	0-15	65.0	5.00	70.00	8.00	22.00	0.36	LS
	15-30	65.10	5.25	70.25	8.10	21.65	0.37	LS
Mean		**74.33**	**9.77**	**84.08**	**5.13**	**10.65**	**0.52**	
SD		**4.16**	**2.17**	**6.24**	**1.50**	**5.12**	**0.16**	
CV%		**5.60**	**22.20**	**7.40**	**29.20**	**48.10**	**30.80**	

Abbreviations:SL=Sand loam,LS=Loamy sand,SD=Standard deviations,CV=Coefficient of variations

Table 4: Particle size distribution of soil Osissa soil in Ndokwa South Local Government Area, Delta State.

Location	Soil Depth (cm)	Coarse Sand	Fine Sand	Total sand (%)	Silt	Clay	Silt/clay ratio	Textural class
A	0-15	80.00	12.00	92.00	5.00	3.00	1.60	S
	15-30	78.35	12.35	90.70	5.30	4.00	1.33	S
B	0-15	82.20	10.40	92.60	3.40	4.00	0.85	S
	15-30	82.00	10.15	92.15	3.10	4.75	0.65	S
C	0-15	82.35	8.65	91.00	4.75	4.25	1.12	S
	15-30	80.15	8.75	88.93	4.85	6.22	0.78	LS
D	0-15	66.00	10.00	76.0	8.0	16.0	0.50	SL
	15-30	65.10	10.25	75.35	8.15	16.50	0.49	SL
Mean		**78.72**	**10.33**	**89.05**	**4.91**	**46.03**	**0.98**	
SD		**5.60**	**1.43**	**5.88**	**1.60**	**4.50**	**0.39**	
CV%		**7.10**	**13.80**	**6.60**	**32.60**	**74.60**	**39.80**	

Abbreviations:S=Sand,SL=Sandy loam,LS=Loamy sand,SD=Standard deviation,CV=Coefficient of variations

4.5 CHEMICAL PROPERTIES

4.5.1 Oko-anala mapping unit

The results of the chemical properties of the soils are shown in Table 5. Soil pH ranged from 5.5 – 5.8 depicting moderately¯acidic, with a mean value of 5.75 and a coefficient of variation of 2.1% which is least variable. Soil organic matter which decline with depth of profile ranged from 0.75 – 0.92gkg^{-1} with a mean value of 0.84 gkg^{-1} and a coefficient of variation of 7.10% which is least variable These values are low to moderate and within the range established as being okay for crop production. Total nitrogen also followed the same trend as soil organic matter . Total nitrogen was also low to moderate and tend to decline with depth of soil profile. High content was found at the surface horizon of the soils. The value of total nitrogen ranged from 0.21 – 0.77 gkg^{-1} with a mean value of 0.45 gkg^{-1} and coefficient of variation of 53.30gkg^{-1} which is highly variable. The soil available phosphorus ranged from 7.45 – 9.50 mgkg^{-1} with a mean value of 8.59 mgkg^{-1} and a coefficient of variation of 9.2 which is least variable%. .

The exchangeable cations (Ca, Mg, K, Na) were found to vary across mapping unit. The values for Ca ranged from 2.35 – 2.51 cmolkg^{-1}, with a mean value of 2.43 cmolkg^{-1} and a coefficient of variation of 2.10% which is least variable.The content of Mg ranged from 0.34 – 0.57 cmolkg^{-1} with a mean of 0.46 cmolkg^{-1} and a coefficient of variation of 19.60% which is moderately variable. The content of K also ranged from 0.07 – 0.10 cmolkg^{-1} with a mean value of 0.08 cmolkg^{-1} and a coefficient of variation of 12.50% which is least variable, while the content of Na on the other hand ranged from 0.02 – 0.03 cmolkg^{-1} with a mean of 0.02 cmolkg^{-1} and a coefficient of variation. of 50%

which is highly variable. Magnesium was also low to moderate and rated low (1.5-3.0 cmolkg^{-1}) On the other hand,Potassium was low and below the critical level of 0.20 – 0.40cmolkg^{-1} established for the ecological zone, Sodium(Na) was also rated low and below 0.3 – 0.7cmolkg^{-1} establish as critical level for the ecological zone.

The exchangeable acidity ranged from 2.54 – 3.58 cmolkg^{-1} with a mean value of 3.32 cmolkg^{-1} and a coefficient of variation of 13.30% which is least variable. The cation exchange capacity (CEC) of the soil was low to moderate. The values ranged from 9.85 – 11.40 cmolkg^{-1} with a mean value of 10.33 cmolkg^{-1} and a coefficient of variation 4.80% which is least variable. The mean value of CEC for the mapping unit is within the range established as moderate for the ecological zone. The base saturation was 28.13% and a coefficient of variation of 8.90% which is least variable.

4.5.2 Eke-Nkpor-Mapping Unit

The pH of the soil ranged from 4.5 – 5.7 with a mean value of 4.91 and a coefficient of variation of 6.90% which is least variable. The pH can be said to be strongly acidic. Organic matter content ranged from 0.70_0.85 gkg^{-1} with a mean value of 0.80 gkg^{-1} and a coefficient of variation of 3.80% which is least variable.

Generally, the organic matter content of the soil were high at the surface horizon and declined relatively with depth of profile. The total nitrogen was also rated low to moderate (0.28 – 0.72 gkg^{-1}) with a mean of 0.58 gkg^{-1} and a coefficient of variation of 22.4% which implied moderate variability.

Available phosphorus ranged from 7.30 – 8.42 mgkg^{-1} with a mean value of 8.03 mgkg^{-1} and a coefficient of variation of 5.50% which is least variable. Generally, the contents of available phosphorus was more concentrated at the upper horizon due to the accumulation of organic residues and tend to decline with depth as organic matter declined. The contents of Ca, Mg K and, Na respectively had mean values of 3.18 cmolkg^{-1}, 0.49 cmolkg^{-1}, 0.09 cmolkg^{-1} and 0.12cmolkg^{-1} . This values were found to increase with depth of profile and within the established critical levels for crop production in the area. The exchangeable acidity for the unit ranged from 2.45 – 2.56 cmolkg^{-1} with a mean value of 2.52cmolkg^{-1} and a coefficient of variation of 1.60% which is least variable. The cation exchange capacity (CEC) varied within the mapping unit and tend to increase with depth of profile. The values ranged between 9.25-9.85cmolkg^{-1} with a mean value of 9.72cmolkg^{-1} and a coefficient of variation of 2.20% which is least variable Generally cation exchange capacity (CEC) were found to increase with depth of profile .The percent base saturation (%BS) also varied from 31.68-42.69% with a mean value of 39.74% and a coefficient of variation of 14.91% which is least variable.

4.5.3 Orogodo River Mapping Unit

The pH ranged from 4.7 – 5.6 with a mean value of 5.30 and a coefficient of variation of 7.20% which is least variable. The pH was strongly acidic. Soil organic matter ranged from 0.58 – 0.82gkg^{-1} with mean value of 0.70 gkg^{-1} and a coefficient of variation of 11.40% which is least variable. Generally, organic matter was more concentrated at the surface horizon and declined relatively with depth of profile. The mean value for the unit was 0.70gkg^{-1} and a coefficient of variation of 11.40% which is least variation. Total nitrogen was low to moderate (0.25 – 0.35 gkg^{-1}) with a mean value of 0.31gkg^{-1} and a coefficient of variation of 9.7% which is least variable. Available phosphorus ranged from 6.30 – 7.35 $mgkg^{-1}$ with a mean value of 6.90 $mgkg^{-1}$ and a coefficient of variation of 6.10% which is least variable. The content of available phosphorus was more on the upper horizons and tend to decrease in the sub-horizon. The exchangeable cations were relatively low to moderate with mean values of 2.37 $cmolkg^{-1}$, 0.37 $cmolkg^{-1}$, 0.12 $cmolkg^{-1}$ and 0.02 $cmolkg^{-1}$ The value for potassium was relatively low. The Exchangeable acidity ranged from 2.54 – 3.00 $cmolkg^{-1}$ with a mean value of 2.63 $cmolkg^{-1}$ and a coefficient of variation of 6.12%. The cation exchange capacity (CEC) varied within horizons and tend to increase with depth of profile. The values ranged from 7.35 – 8.82 $cmolkg^{-1}$ with a mean value of 8.17 $cmolkg^{-1}$ and a coefficient of variation of 6.70%, which is least variable. Generally, the cation exchange capacity (CEC)was found to increase with depth of profile and rated moderate for crop production. The percent base saturation(% BS) also ranged from 31.20 – 40.00% with a mean value of 36.71 and a coefficient of variation of 12.80 which is least variable.

4.5.4 Ossissa Mapping Unit

The soil pH ranged from 4.8-5.8 with a mean value of 5.20 and a coefficient of variation of 5.90% which is least variable. Soil organic matter ranged from 0.62 – 0.85 gkg^{-1} and a mean value of 0.77 gkg^{-1} and coefficient of variation of 9.10%. Total nitrogen content however declined with depth of profile and this ranged from 0.32 – 0.52 gkg^{-1} with a mean value of 0.43 gkg^{-1} and a coefficient of variation of 18.60% which is moderately variable. The soil available phosphorous also range from 7.32 – 7.75 mkg^{-1} with a mean value of 7.52 mkg^{-1} and a coefficient of variation of 2.80%. The phosphorous content is rated low to moderate. The exchangeable cations varied across horizons in the mapping unit and the values ranged from 2.35 – 2.47 $cmolkg^{-1}$ for calcuim with a mean value of 2.41 $cmollkg^{-1}$ and a coefficient of variation of 1.70% which is least variable. The contents of Mg ranged from 0.23 – 0.43 $cmolkg^{-1}$ with a mean value of 0.32 $cmolkg^{-1}$ and a coefficient of variation of 25.00% which is moderately variable.

The content of potassuim (K) also range from 0.09 – 0.15 $cmolkg^{-1}$ with a mean value of 0.13$cmolkg^{-1}$ a coefficient of variation of 15.40% which is moderately variable. The value of sodium (Na) ranged from 0.02 – 0.03 $cmolkg^{-1}$ with a mean of 0.03$cmolkg^{-1}$ and a coefficient of variation of 10.00% which is least variable. The exchangeable acidity was high (2.47--2.57 $cmolkg^{-1}$) with a mean of 2.50$cmolkg^{-1}$ and a coefficient of variation of 1.60% which is least variable.. The cation exchange capacity (CEC) had values range from (8.75 – 9.80$cmolkg^{-1}$) a mean of 8.89$cmolkg^{-1}$ and coefficient of variation of 1.90% which is least variable. The percent base saturation (% BS) ranged from 29.18 – 35% with a mean value of 32.50% and a coefficient of variation of 5.40% which is considered least variable.

Table 5: Some Chemical Properties of soils derived from Oko-anala mapping units in Oshimili South Local Government Area of Delta State, Nigeria.

Location	Soil Depth (cm)	Soil pH (H_20)	Organic carbon (gkg^{-1})	Total N (gkg^{-1})	Avail. P ($mgkg^{-1}$)	Exchangeable cations ($Cmolkg^{-1}$) Ca	Mg	K	Na	EA ($cmolkg^{-1}$)	CEC $cmolkg^{-1}$	% BS
A	0-15	5.6	0.87	0.24	7.45	2.47	0.54	0.07	0.03	2.57	9.85	31.57
	15-30	5.8	0.85	0.21	7.82	2.51	0.57	0.10	0.03	2.54	9.95	32.26
B	0-15	5.7	0.92	0.31	8.31	2.38	0.48	0.08	0.03	3.25	10.15	29.26
	15-30	5.8	0.85	0.28	8.30	2.42	0.51	0.10	0.03	3.27	10.20	30.00
C	0-15	5.6	0.78	0.77	9.50	2.40	0.35	0.07	0.02	3.45	10.35	27.44
	15-30	5.5	0.75	0.75	9.45	2.45	0.45	0.09	0.02	3.42	10.45	28.80
D	0-15	5.8	0.83	0.56	8.75	2.35	0.34	0.08	0.02	3.56	11.35	24.58
	15-30	5.6	0.80	0.52	8.70	2.38	0.38	0.10	0.02	3.58	11.40	25.26
Mean		**5.7**	**0.84**	**0.45**	**8.51**	**2.43**	**0.46**	**0.08**	**0.02**	**3.15**	**10.33**	**29.13**
SD		**0.12**	**0.06**	**0.24**	**0.78**	**0.05**	**0.09**	**0.01**	**0.01**	**0.42**	**0.50**	**2.59**
CV%		**2.1**	**7.10**	**53.30**	**9.20**	**2.10**	**19.60**	**12.50**	**50.00**	**13.30**	**4.80**	**8.90**

Table 6: Some Chemical Properties of soils derived from Eke-Npkor-Anwai mapping units in Oshimili North Local Government Area,Delta State

Location	Soil Depth (cm)	Soil pH (H_2O)	Organic carbon (gkg^{-1})	Total N (gkg^{-1})	Avail. P ($mgkg^{-1}$)	Exchangeable cations ($Cmolkg^{-1}$) Ca	Mg	K	Na	EA ($cmolkg^{-1}$)	CEC $cmolkg^{-1}$	% BS
A	0-15	4.6	0.82	0.72	8.35	3.35	0.52	0.09	0.12	2.45	9.82	41.55
	15-30	5.3	0.80	0.70	8.32	3.40	0.55	0.12	0.12	2.47	9.85	42.69
B	0-15	4.5	0.83	0.65	8.42	3.25	0.50	0.08	0.12	2.47	9.75	40.51
	15-30	4.8	0.78	0.60	8.40	3.30	0.52	0.12	0.12	2.48	9.80	41.43
C	0-15	4.7	0.85	0.58	7.75	3.21	0.47	0.08	0.12	2.54	9.75	39.80
	15-30	5.2	0.80	0.50	7.65	3.25	0.49	0.12	0.12	2.56	9.82	40.52
D	0-15	5.3	0.75	0.35	7.35	2.47	0.35	0.08	0.03	2.48	9.25	31.68
	15-30	5.7	0.70	0.28	7.30	2.50	0.38	0.10	0.03	2.52	9.30	32.37
Mean		**4.91**	**0.80**	**0.58**	**8.03**	**3.18**	**0.49**	**0.09**	**0.12**	**2.50**	**9.72**	**39.74**
SD		**0.34**	**0.03**	**0.13**	**0.44**	**0.32**	**0.07**	**0.02**	**0.03**	**0.04**	**0.21**	**3.67**
CV%		**6.9**	**3.8**	**22.40**	**5.50**	**10.10**	**14.30**	**22.20**	**25.00**	**1.60**	**2.20**	**9.20**

Table 7: Some Chemical Properties of soils derived from Orogodo mapping units in Agbor Ika South Local Government Area, Delta State, Nigeria

Location	Soil Depth (cm)	Soil pH (H_20)	Organic carbon (gkg^{-1})	Total N (gkg^{-1})	Avail. P ($mgkg^{-1}$)	Exchangeable cations ($Cmolkg^{-1}$) Ca	Mg	K	Na	EA ($cmolkg^{-1}$)	CEC $cmolkg^{-1}$	% BS
A	0-15	5.4	0.82	0.35	6.75	2.35	0.42	0.12	0.02	2.57	7.35	39.59
	15-30	5.6	0.75	0.30	6.72	2.38	0.45	0.13	0.02	2.58	7.45	40.00
B	0-15	5.4	0.75	0.32	7.25	2.35	0.35	0.10	0.02	2.58	8.35	33.77
	15-30	5.7	0.72	0.30	7.35	2.37	0.40	0.12	0.02	3.00	8.50	34.24
C	0-15	4.7	0.65	0.30	6.35	2.35	0.32	0.12	0.03	2.56	8.35	33.77
	15-30	4.8	0.60	0.25	6.30	2.38	0.35	0.15	0.03	2.60	8.45	44.44
D	0-15	5.3	0.60	0.35	7.25	2.34	0.30	0.07	0.02	2.54	8.75	31.20
	15-30	5.6	0.58	0.30	7.30	2.37	0.32	0.10	0.02	2.58	8.82	31.85
Mean		**5.30**	**0.70**	**0.31**	**6.90**	**2.36**	**0.37**	**0.12**	**0.02**	**2.63**	**8.17**	**36.71**
SD		**0.38**	**0.08**	**0.03**	**0.42**	**0.02**	**0.05**	**0.03**	**0.01**	**0.16**	**0.55**	**4.70**
CV%		**7.20**	**11.40**	**9.70**	**6.10**	**0.90**	**13.50**	**25.00**	**50.00**	**6.10**	**6.70**	**12.80**

Table 8: Some Chemical Properties of soils derived from Ossissa mapping units in Ndokwa South Local Government Area, Delta State, Nigeria

Location	Soil Depth (cm)	Soil pH (H_20)	Organic carbon (gkg^{-1})	Total N (gkg^{-1})	Avail. P ($mgkg^{-1}$)	Exchangeable cations ($Cmolkg^{-1}$) Ca	Mg	K	Na	EA ($cmolkg^{-1}$)	CEC $cmolkg^{-1}$	% BS
A	0-15	5.2	0.82	0.34	7.75	2.45	0.40	0.12	0.03	2.53	8.75	34.29
	15-30	5.5	0.78	0.32	7.72	2.47	0.43	0.15	0.03	2.55	8.80	35.00
B	0-15	4.8	0.85	0.43	7.38	2.35	0.35	0.12	0.03	2.48	8.80	32.39
	15-30	5.3	0.83	0.40	7.35	2.37	0.37	0.15	0.03	2.50	8.82	33.11
C	0-15	5.2	0.75	0.52	7.38	2.38	0.23	0.12	0.03	2.54	9.10	30.33
	15-30	5.6	0.72	0.51	7.32	2.40	0.25	0.14	0.03	2.57	9.15	30.81
D	0-15	4.8	0.65	0.48	7.75	2.42	0.25	0.09	0.02	2.47	8.78	31.66
	15-30	5.5	0.62	0.45	7.65	2.45	0.27	0.12	0.02	2.56	9.80	29.18
Mean		**5.20**	**0.77**	**0.43**	**7.52**	**2.41**	**0.32**	**0.13**	**0.03**	**2.52**	**8.89**	**32.50**
SD		**0.31**	**0.07**	**0.08**	**0.21**	**0.04**	**0.08**	**0.02**	**0.03**	**0.04**	**0.17**	**1.74**
CV%		**5.90**	**9.10**	**18.60**	**2.80**	**1.70**	**25.00**	**15.40**	**10.00**	**1.60**	**1.90**	**5.40**

4.6 Nitrate Nitrogen content

The results of the nitrate nitrogen content of the soils are shown in Table 9. The soils varied slightly in their contents of nitrate-nitrogen and were not significantly different in depth. The contents of nitrate nitrogen irrespective of mapping units ranged from 0.08 $mgkg^{-1}$ at the top soil horizons to 0.21 $mgkg^{-1}$ at the sub soil horizons. The general observation in this study was that nitrate nitrogen was found to concentrate in the sub soil horizon than the top soil horizon.

Table 14: Comparing Nitrate – Nitrogen Concentration with other metallic elements in the soils against the UNEP Standards

Elements	UNEP Limits (mg/kg)	Critical values (mg/kg^{-1})
Zn	300 – 450	470 – 520
Fe	150 – 210	250 – 350
Cu	100 – 175	180 – 195
Pb	120 – 150	165 – 185
Cr	10 – 25	28 – 35
NO_3-N	0.35 – 4.20	4.75 – 5.20

Source: Procedure of the International Symposium on solid waste management for developing countries. Karisruthe, Federal Republic of Germany, UNEP and BMFT.

Table 9: Nitrate Nitrogen (NO_3-N) contents of the cultivated soils of the study area

Soil mapping units	Soil depth (cm)	Test crops		
		Telfairia occidentalis	***Amaranthus cruentus***	***Abelmoschuc esculentus***
Oko-Anala	0 – 15	0.25a	0.36[a]	0.22[a]
	15 – 30	038[b]	0.42[b]	0.37[b]
Eke-Nkpor	0 – 15	0.30[a]	0.28[a]	0.12[a]
	15 – 30	0.44[b]	0.38[b]	0.27[b]
Orogodo	0 – 15	0.45[a]	0.47[a]	0.15[a]
	15 – 30	0.52[b]	0.56[b]	0.28[b]
Osissa	0 – 15	0.38[a]	0.36[a]	0.35[a]
	15 –30	0.47[b]	0.42[b]	0.48[b]

Means with the same letters under the same column are not significantly different ($P < 0.05$) levels of probability

4.8 Plant Tissue Analysis

The results of the plant tissue analysis aimed at establishing uptake of NO_3^-N are presented in Tables 10 -13. The results showed that the rate of nitrate nitrogen uptake varied across individual farmer's plot and locations. For instances in Oko-anala, (Table 10), Eke-Nkpor (Table 11) and Ossissa (Table 12) where not much nitrogenous fertilizers were, the uptake varied from 0.03 mgkg^{-1} to 0.07 mgkg^{-1} *for Telferia occidentalis*, 0.05 mgkg^{-1} to 0.12 mgkg^{-1} for *Amaranthus cruentus* and 0.03 mgkg^{-1} – 0.09 mgkg^{-1} for *Abelmuscus esculentus*.respectively The same variations were also observed in Eke-Nkpor and Ossissa. However, in Orogodo flood plain where commercial vegetable production is done at its highest level and all inputs (fertilizers), it was clearly observed that nitrate-nitrogen (NO_3-N) uptake were quite high across the evaluated crops (Table 12). The uptake varied from 0.22 mgkg^{-1} to 0.28 mgkg^{-1} for *Telfairia occidentalis,* 0.23 mgkg^{-1} to 0.38 mgkg^{-1} for *Amaranthus cruentus* and 0.03 – 0.07 mgkg^{-1} for *Abelmoschuc esculentus,* respectively.

In all the test crops evaluated, the least uptake of nitrate-nitrogen was Okra (*Abelmoschuc esculentus*) with cumulative values of 0.03 mgkg^{-1} to 0.27 mgkg^{-1}. This was followed by *Telfairia occidentalis* (fluted pumpkin) 0.03 – 0.30 mgkg-1. The highest uptake was observed with *Amaranthus cruentus* (green vegetables). The uptake ranged from 0.23 mgkg^{-1} to 0.38 mgkg^{-1} (Table 12).

Table 10: Uptake of Nitrate Nitrogen (NO_3-N) as influenced by test crops in the individual farm units in Oko-Anala mapping unit

Farmer's Plot	Replicate samples	Test crops		
		Telfairia occidentalis	*Amaranthus cruentus*	*Abelmoschuc esculentus*
1	A	0.03	0.09	0.05
	B	0.05	0.09	0.04
	C	0.03	0.11	0.07
	D	0.05	0.07	0.03
	E	0.04	0.12	0.06
	$\bar{x}$	0.04	0.09	0.05
2	A	0.06	0.10	0.04
	B	0.05	0.07	0.04
	C	0.07	0.10	0.08
	D	0.03	0.05	0.05
	E	0.05	0.10	0.10
	$\bar{x}$	0.04	0.08	0.06
3	A	0.04	0.12	0.03
	B	0.04	0.08	0.03
	C	0.06	0.08	0.07
	D	0.03	0.10	0.05
	E	0.03	0.07	0.09
	$\bar{x}$	0.04	0.09	0.06
4	A	0.05	0.11	0.04
	B	0.03	0.10	0.02
	C	0.05	0.12	0.06
	D	0.07	0.07	0.05
	E	0.05	0.06	0.07
	$\bar{x}$	0.05	0.09	0.05

Table 11: Uptake of Nitrate Nitrogen (NO_3-N) as influenced by test crops in the individual farm units in Eke-Nkpor mapping unit

Farmer's Plot	Replicate samples	Test crops		
		Telfairia occidentalis	*Amaranthus cruentus*	*Abelmoschuc esculentus*
1	A	0.05	0.12	0.04
	B	0.03	0.13	0.06
	C	0.05	0.18	0.05
	D	0.07	0.17	0.08
	E	0.05	0.13	0.05
	$\bar{x}$	0.05	0.15	0.06
2	A	0.03	0.15	0.03
	B	0.03	0.18	0.03
	C	0.05	0.12	0.08
	D	0.04	0.13	0.05
	E	0.07	0.15	0.06
	$\bar{x}$	0.04	0.15	0.05
3	A	0.07	0.13	0.05
	B	0.04	0.12	0.05
	C	0.03	0.15	0.08
	D	0.08	0.17	0.10
	E	0.07	0.13	0.12
	$\bar{x}$	0.06	0.14	0.08
4	A	0.06	0.07	0.07
	B	0.07	0.12	0.06
	C	0.07	0.11	0.05
	D	0.08	0.09	0.07
	E	0.10	0.18	0.08
	$\bar{x}$	0.08	0.11	0.07

Table 12: Uptake of Nitrate Nitrogen (NO_3-N) as influenced by test crops in the individual farm units in Orogodo mapping unit

Farmer's Plot	Replicate samples	Test crops		
		Telfairia occidentalis	*Amaranthus cruentus*	*Abelmoschuc esculentus*
1	A	0.25	0.31	0.05
	B	0.27	0.32	0.07
	C	0.28	0.29	0.03
	D	0.27	0.33	0.08
	E	0.23	0.35	0.06
	$\bar{x}$	0.26	0.32	0.06
2	A	0.28	0.34	0.04
	B	0.22	0.35	0.04
	C	0.27	0.29	0.07
	D	0.23	0.33	0.05
	E	0.22	0.36	0.08
	$\bar{x}$	0.24	0.33	0.06
3	A	0.27	0.33	0.05
	B	0.28	0.37	0.07
	C	0.23	0.35	0.07
	D	0.27	0.37	0.03
	E	0.25	0.34	0.06
	$\bar{x}$	0.26	0.35	0.06
4	A	0.27	0.34	0.05
	B	0.26	0.38	0.04
	C	0.27	0.38	0.03
	D	0.23	0.36	0.07
	E	0.28	0.35	0.08
	$\bar{x}$	0.26	0.36	0.05

Table 13: Uptake of Nitrate Nitrogen (NO_3-N) as influenced by test crops in the individual farm units in Osissa mapping unit

Farmer's Plot	Replicate samples	Test crops		
		Telfairia occidentalis	*Amaranthus cruentus*	*Abelmoschuc esculentus*
1	A	0.23	0.31	0.21
	B	0.20	0.33	0.18
	C	0.25	0.29	0.17
	D	0.28	0.32	0.22
	E	0.29	0.35	0.20
	$\bar{x}$	0.25	0.32	0.20
2	A	0.27	0.34	0.23
	B	0.27	0.32	0.21
	C	0.25	0.37	0.19
	D	0.28	0.33	0.25
	E	0.27	0.31	0.22
	$\bar{x}$	0.27	0.33	0.22
3	A	0.27	0.33	0.20
	B	0.27	0.34	0.19
	C	0.21	0.29	0.23
	D	0.25	0.37	0.18
	E	0.26	0.31	0.19
	$\bar{x}$	0.25	0.33	0.20
4	A	0.24	0.29	0.22
	B	0.31	0.37	0.19
	C	0.29	0.35	0.23
	D	0.28	0.37	0.25
	E	0.30	0.38	0.27
	$\bar{x}$	0.28	0.35	0.23

CHAPTER FIVE

DISCUSSION

5.1 Physical properties of the soil

The particle size distribution which describes the relative percentage of sand, silt,and clay of a given soil, showed that the soils of the study areas were dominantly sandy at the surface horizons which tend to decrease relatively with profile depth. The clay content were higher in the lower horizons. The dominant sand content at the upper horizons could be attributed to the sandy nature of the parent material. On the other hand, the increase in depth with clay could be as a result of illuviation of clay down the sub soil horizon profile. Furthermore, clay illuviation into the lower horizons also suggests pedogenetic processes of argillation which are wide spread occurrence in inter tropical soils (Amalu *et al.*, 2001).The same observations have been reported by Ojanuga (1991) and Ayolagha (2001) with respect to particle size distribution in soils of alluvial deposits in Nigeria. The silt/clay ratio across the mapping units which varied from 0.29 – 0.78 was an indication that the soils were of young parent materials with low degree of weathering. Ayolagha (2001) , Van-Alphen and Stroorvogel, (2000) reported that soils with silt/clay ratios of less than 0.15 are of old parent materials indicating recent pedogenetic processes.

5.2 Chemical Characteristics

The soil pH across the mapping units ranged from moderately to strongly acidic. The general acidic nature of the soils could be attributed to high rainfall nature of the environment, excessive leaching, bush burning especially during the off flood cycles and redox product of ferrolysis. This finding is in line with the work of Akpan-Idiok *et al.*, (2001) and Egbuchua, (2011). The organic matter contents were low to moderate in all the pedons studied and were more concentrated on the surface horizons than in the sub surface horizons. The low to moderate organic matter contents could be attributed to intensive cultivation of the soils, excessive burning during off planting seasons and non-return of harvested crop residues back to the soil after harvest(Amalu et al,2001). On the other hand the moderate content could be attributed to residues left on the soil after flooding and as flooding recedes. The same findings have been reported by Akpan – Idiok *et al.*(2001).and Maniuyunda and Malgwi, (2011). The findings in the study however, disagreed with the work of Egbuchua, (2011) who reported higher organic matter content in some alluvial soils of Delta State, Nigeria. The reason he gave was that when the flood recedes all alluvial transported materials are usually left behind thereby increasing the organic matter content of the soil. Total nitrogen on the other hand, was relatively low to moderate across the mapping units. This could be attributed to the low to moderate organic matter content of the soil which contributes about 70-75% soil organic nitrogen (Agboola, 1993). Other reasons that could have caused low total nitrogen include nitrate leaching and continuous cultivation of the soils year in and year out without replenishing them with mineral fertilizers as well as frequent bush burning which tends to destroy the organic carbon cycle of the soil (Agboola, 1993, Akpan-Idiok *et al.*, 2001, Egbuchua, 2011). On the other hand the moderate value could be as a result of mineralized organic residues that were left during flood cycles. Available phosphorus was also low to moderate and within the range established for the ecological zone. The low to moderate phosphorus content could also be attributed to the low organic matter contents of the soils as well as phosphorus fixation by sesquioxides (Raji *et al.,* 2001, Nsokpo and Ibanga, 2001), respectively. On the other hand the moderate content of phosphorus could be attributed to the greater diffusion of phosphorus, dissolution of occluded phosphorus and reduction of Fe – P in hydromorphic soils (Sanchez 1976). The exchangeable cations were low to moderate. This is an indication that the soils were of the 1:1 clay mineralogy. It could also be attributed to the leaching effects of the basic cations due to erosion and low organic matter status of the soil resulting from annual bush burning and continuous cultivation during off flood cycle. This fact is in consistent with the findings of Akpan-Idiok *et al.,(* 2001), Akamigbo *et al.,* (2001). Soduim content was generally low. The low sodium content of the soils was an indication that the soils of the study areas are not saline in nature. The cation exchange capacity (CEC) was low to moderate depicting the clay mineralogy of the soils and low to moderate contents of the basic cations as exemplified in the study areas.

5.3 Nitrate Nitrogen (NO_3^-N)

The nitrate nitrogen content across the mapping units studied were generally low, and tend to increase down the soil profiles. This vividly indicated a gradual leaching of nitrate-nitrogen down the profile. In the studies of Mc Neal *et al.,*(1995), Cui *et al.,*(2008) respectively, they reported an increase in nitrate-nitrogen in the sub-soil horizons than in the upper soil horizons. They attributed such phenomenon to the leaching of nitrate-nitrogen down the profiles. Another reason they gave, was the high mobility of nitrates in the soil due to the negative charge it possess. This negative charge makes it not to be absorbed by most soil colloids thereby rendering it most susceptible to leaching than other form of nitrogen. The likely problems due to the leaching of nitrate – nitrogen (NO_3^-N) down the lower horizons include the contamination of domestic wells, streams and estuaries (Brady and Weil, 2007, Cui *et al.*, 2007). In addition, Brady and Weil,(2007), have also emphasized that excess nitrate-nitrogen leaching in any given soil where ammonium fertilizers were applied for the growth of vegetables could facilitate the loss of calcium and other cations thereby leading to loss of soil quality. Studies have shown that continuous application of nitrogenous fertilizers especially in the forms of Ammoniun nitrate (NH_4NO_3) could improve yield and crop production but the risk of increase in the levels of potentially persistence organic toxic material over time is there (Nriagu,1998). Ezeaku *et al.,* (2005) have also reported that long term application of Nitrogenous fertilizers could undoubtedly improve soil fertility and provides crop nutrients needs of the farmer. However ,such continuous applications could result to negative and harmful changes in soil physical and chemical characteristics due to increase toxicity and phytotoxicity on the soils.

5.4 Permissiable Level of Consumption

The United Nation Environmental Protection (UNEP) tolerable contents of certain elements in respect to cultivated soil with regards to health of soil, vegetation, livestock and man was compared with the data obtained for nitrate-nitrogen in the study areas (Table 14). It was observed that the nitrate-nitrogen contents of the soils were within the permissible level when assimilated through consumptions of the vegetables. The implication is that Nitrate-nitrogen applied through fertilizers do not pose any problem if the rates of application were as required by crops. However, continuous applications over time, and higher rates of applications could result to toxicity and these could have harmful effects to both man and animals when crops cultivated on these soils are ingested. Against this background, NO_3^-N content in soil of cultivated vegetables should be monitor regularly.

CHAPTER SIX

Summary, Conclusions ,Recommendations And Contribution to Knowledge

6.1 Summary

The study was conducted in four locations of alluvial soils complex namely Oko-anala, Eke-Nkpor, Orogodo and Ossissa flood plains in Delta state,Nigeria. The aim was to investigate the nitrate nitrogen (NO_3^-N) status and related elemental nutrient contents of the soils in relation to vegetable production. The vegetable crops used for the study were *Telfairia occidentalis* (fluted pumpkin), *Amaranthus cruentus* (Green vegetable),and *Abelmoschuc esculentus* (Okra). These crops were chosen based on their magnitude of demand and consumption within the localities. Field mapping was carried out and four distinct land areas measuring 10m x 20m mapped out and mini profile pit dug to 30cm depth. Soil sample were collected from pedogenetic soil depths of 0-15,and 15-30cm respectively. From each of the sample locations, four (4) farmers farms were sampled individually and five test crops taken from the farmer's plot. The leaf samples were digested using appropriate methods as described by Agbenin (1995). Samples for soil analysis were also collected and determined using the appropriate methods. Data collected were subjected to simple statistics while difference in mean were separated using New Duncan Multiple Range Test (New DMRT). The results of the study showed that nitrate-nitrogen content were low in all the mapping units studied. These were significantly different ($P > 0.05$) at 5% level of probability. The physico-chemical properties of the soils showed that the texture of the soil varied from sandy clay loam to sandy loam. Chemical data showed that soil were acidic in nature. The attributes of organic carbon, total nitrogen and available phosphorus were all low to moderate depicting the intensive use of the soil year in and out for crop cultivation especially, the arable crops. The basic cations were also low to moderate depicting the 1:1 clay mineralogy of the soils. The nitrate nitrogen level were also within the permissiabe limit of 0.35mgkg^{-1} recommended for uptake by plant for both animals and human consumptions. On the other hand, NO_3^- N content of the soil was found to increase with depth of profiles due to downward leaching processes

6.2 Conclusion

The soils of the study areas were generally low in nitrate-nitrogen and the contents were within the permissible level of consumption of vegetables grown on them. In all the profiles studied, nitrate - nitrogen (NO_3^-N) was found to increase with depths of profiles indicating nitrate-nitrogen leaching. Other parameters investigated in the study (physio-chemical properties) showed low to moderate contents. This is an indication that the soils could be productively ultilized agriculturally through judicious application of recommended rate of nutrients particularly inorganic nitrogenous fertilizers. Leaching of nitrates down the subsoil horizons is common and this could cause environmental pollution. This becomes very obvious because nitrates are known to move very freely with drainage water.and because of this, they are leached with ease from the soil and this could cause eutrification.

6.3 Recommendations

Because of the hazards associated with excessive application of nitrogenous based fertilizers both to man, animal and the environment, it is strongly recommended that judicious application of recommended rates of nutrients particularly inorganic nitrogen fertilizers should be strictly adhere to in order to avoid possible accumulation of nitrates (NO_3^-N) down the profile thereby causing environmental pollutions.

6.4 Contribution to Knowledge

The study established that:

1. Plant absorbed nitrate nitrogen when they are applied in excess.
2. Nitrate nitrogen absorption was found to be much higher in *Amanranthus cruentus* compare to the other test crop study.
3. Nitrate nitrogen was found to concentrate more at the sub soil horizon, these is because there are easily leached down the soil and thus has the potential of underground water pollution which could be hazardous to both man and animals.

REFERENCES

Agbeni, J.O.(1995): Laboratory manual for soil and plant analysis. Department of soil science Ahmadu Bello University, Zaria 140p

Agboola, A. A. (1993): Soil Test Calibration For Lowland rice in South West, Nigeria Fertilizer Research 14:227-234.

Agusiobu, O. V. (2001): Vegetable gardening Nutritional value of vegetable. 1st Publication Macmillan Education Limited London and Basing Stokes pp.2

Akamigbo F.O.R., Ezedinma, F. O. C and Igwe C. A.(2001): Properties and Classification sof Some Alluvial Soils of Nigeria. In proceeding of the 27th Annual Conference of Soil Science Society of Nigeria. Pp57

Akamigbo, F. O. R (2001): Survey, Classification and Land use of wetland soils in Nigeria. In: proceedings of the 27th Annual Conference of the Soil Science Society of Nigeria held in Calabar, Nigeria, 5-9 November.pp115

Akpan-Idiok, A. U. and Esu, I. E. (2001): Morphological characteristics and classification of mangrove swamps soils in Cross River estuary in South East, Nigeria. Proceedings of the 27th Annual Conference of the Soil Science Society of Nigeria 5th-9th November, 2001. Calabar, Nigeria.pp87

Amalu, U. C. E. Esu and M.V.N. Nwulu (2001): Fertility Management of some gleic luvisols and Alisols grown to rice in the South East, Nigeria. Proceedings of 27th Annual Conference of the Soil Science Society of Nigeria, 5th-9th November, 2001, Calabar, Nigeria.pp 157

Ayolagha, G. A. (2001): Survey & Classification of Yenogoa meander belt soils in the Niger Delta. Proceedings of the 27th Annual Conference of the soil science society of Nigeria, 5th – 9th Nov., 2001, Calabar, Nigeria. Pp100

Brady,N.C and Ray,R.W (2007): The nature and properties of soils.13th Edition,Pearson and prentice Hall Publisher.pp97.

Brinkman, R. and W. A. Blokhuis (1986): Classification of the soils of wetlands sub-Saharan African p. 31-42. In Jou A. S. R. and J. A. Iowe (ed.) The wet lands and rice in Sub-Saharan Africa Proceedings of International Conference in Wetlands utilization 4-8 November 1985 Lita Ibadan.pp 154

Chude, V. O. (1998): Understanding Nigerian Soil and their fertility management for sustainable agriculture. Inaugural Lecture Series 13. Ahmadu Bello University, Zaria, Nigeria 33p.

Cui,Z.F,Zhang.Y,Miao Q. S,Lui.c (2008):Soil nitrate-N levels required for high yield maize production in the North China plain. Nutr,cycle.Agroecosystem:82:187-196.

Eckert,D.(2008):Efficient fertilizer use nitrogen.http,www.mossaico.co/fertilizer/nitrogen (Retrieved may 26, 2008).

Edmonds, J. K. (1991): The distribution of Hibiscus L. section furcaria in tropical Rome. IBPGR Publishers Rome.

Egbuchua C.N (2011): A pedological characteristics of soil of River Niger Alluvial complex of Nigeria. Nigeria journal of soil and Environmental research.Published by dept of soil science, Ahmadu Bello University,Zaria.pp71-77.

Enweazor, W. O. Ohiri, A. C. Opuwaribo and Udo E. J. (1990): Lit. review on soil fertility investigation in Nigeria. (In five volumes) produced by the Federal Ministry of Agric & Natural Resources, Lagos.pp80

Eshett E.T. (1993): The wetland soils of Nigeria properties. Classification and traditional land use practices wetlands and ecotones studies on land water interaction p.227-244.

Esu,I.E (2004): Soil characterization and mapping for food security and sustainable environment of Nigeria. In proceeding of the 29th Annual conference of soil science of Nigeria. University of Agriculture, Abeokuta, Nigeria.pp9-25.

Ezeaku, P. I. Olimah J. A. and Amakhiau (2003): Significant of soil characteristics to urban waste disposal in urban land in proceedings of the 28th Annual Soil Science Society of Nigeria. P. 220-223.

FAO/ UNESCO (1974): Soil map of the World: 5,000,000 volume 1 Legend UNESCO Paris, France.

Gee and Bauder (1986)particle size analysis.In A.Klute edition. Method of soil analysis.part 1 2 nd edition. Agronomy monograph p 404-407

Grubben, G. I. W. (1977): Tropical vegetable and their genetic resources. Rome: IBPGR.

Grubben,G.J.H, and Denton, O.A.(2004): Plant resources of tropical of tropical African 2.Vegetables.PROTEA foundation, Wageningen;leiden;CTA,Wageningen pp11-15.

Havlin,J.L;Beaton,D,Tisdale.S.L and Nelson,W,L.(2006).Soil fertility and fertilizers,7th (Ed). Prentice Hall of india private limited.New Delhi,pp160-198.

Holland, M. A., Allen R. K. G., Barton, D. and Murphy, S. T. (1989): Land evaluation and agricultural recommendations: Cross River National Park, Oban Division, ODNRI, WWF Nigeria and CRS Government P41-42.

Kirby, R. H. (1993): Vegetable fibres, Leonard Hill Publishers.

Kyuma, K. (1995): Fundamental characteristics of wetland soil. In proceeding of a workshop on wetland soils. Characterization classification utilization, 25th March-5th April, 1994, Los Banos, Philippines.

Lekwa M. U. Akamigbo, F. O. R. and Lekwa G. (2001): A detailed soil survey of the soil of Igwu river flood plain, Arochukwu L.G.A, Abia State of Nigeria for swamp rice production.

Maniyunda, L. M. Kalgwi, W. B. (2011): Physico-chemical properties and management strategies for soil along River Galma, Zaria, Nigeria in proceedings of the 35th Annual Conference of the Soil Society of Nigeria, Pg. 53.

Marschner,H,(1999): Mineral nutrition of higher plants.Academic press,London,889.

Mc Neal, B.L. Stanley, W.D., Graham, P. R., Cul, PR., Downey, D. and Greiglon J. F. (1995): Nutrient loss trends for vegetable and citrus field in West Florida. Nitrate Journal of Environmental Quality 25: 95-100.

Nitrate and Nitrite poisoning introduction: The Merck veterinary manual,Retrieved, 2008.pp12-27

Nniagu, J. O. (1998): A silent epidermic of environmental poisoning. Journal of Environmental Pollution. p. 139-161.

Nsokpo, E. E. and I. Ibanga(1986): Fertility status of selected hydromorphic soil in Akamkpa LGA, Cross River State in Proceedings with the 27th Annual Conference of the Soil Society of Nigeria. Pg 161.

Obiakor,P.O (1971):The Nigeria civil war implication, experience and alternatives to blockages.Zion publishers pp215.

Odingo, R. S. (1991): Research and Development of land use policies in Africa. Paper presented for the United Nations University Project on the Institute of National Resource in Africa (UNUINRA) Nairobi, Kenya.

Ojanuga, A. G. (1991): Characteristics of soils of semi arid regions of Nigeria. In Sagua, Y. O. (ed.) Ecoloigcal disaster in Nigeria. Drought and Desertification.

Okusami, T. A. and R. H. Rust, (1992): Occurrence characteristics and classification of some hydromorphic soils from South Nigeria. In Correlation meeting (viii ISCOM) characterization, classification and utilization of wet soils USDA. Soil conservation service, national Soil Survey Centre, Lincoln.

Raji, B. A. Malagwi, W. R. Falaki and Kparmwang T. (2001): Characterization and classification of soils of the alluvial complex in the semi-arid region of Nigeria. In: proceedings of the 27th Annual Conference of the Soil Science Society of Nigeria.

Roth, G. W. and Fox R. H. (1990): Soil nitrate accumulation following a nitrogen fertilized corn in Pennsylvania. Journal of Environmental Quality 9: 243-248.

Sanchez, P. A. (1976): Properties and Management of soils in the tropics. John Wiley and Sons, New York 618p.

Sogbedgi, J. M. M, Vanes and C. L. Yang (2000): Nitrate leaching and nitrogen budget as affected by maize, nitrogen rate and soil type. Journal of Environmental Quality 29:1813-1820.

Stevevson,M.C.(1915): Ethnobotany of the Zuni Indians, SI-BAE. Annual Report pp30,pp 87.

Stoltenow,C and Grey L,(2008): Nitrate poisoning of livestock.North Dakota state university pp 1-4.Retrieve October 30,pp 20

Stoops.G and Eswaran H,(1986): Fundamental characteristics of wetlands soils.In proceedings of workshop held 27 march to April 5 1984 under the joint sponsorship of the international Rice Research institute.pp177-190.

Udo, E. J (2001): Nutrient status and Agricultural potential of wetland soils. In Proceedings of the 27th Annual Conference of Soil Science Society of Nigeria.

Ufot, U, Okere, J. U., Anene, B. O. A and Ugwu, T.O. (2001): Properties, classification and site suitability evaluation of some wetland soils of Nigeria.

Van Alphen, B. J. and J. J. Stoornogel (2000): A functional approach to soil characterization in support of precision agriculture. Soil Science Society American Journal 64. 1706-1713.

Van Mensuoort, M. E., Lantin R. S. Brinkman, R. and Van Breemen N: Toxicities of wetland soils. In: proceedings of a workshop held 26 March to 5th April, (1984): The International Rice Research Institute.

Vegetable research (2000): Commercial vegetable production. North Williamatte, Research and Extension Center, West Oregon, USA.

Vink A. P.A. (1975): Land use:In advancing agriculture,394pp, Springe Verlag Berlin, H.Fedelberg New York.

Walkley.A and Black,I.A(1934): Determination of organic matter in soil. Soil science 37,549-556.

Wilding L. P. and Rehage J. A. 1986. Pedogenesis of soils with aquic moisture regimes.

Yakubu, A. A., Bashir, A and Noma, S. S. (2004): Soil Chemical properties of Fadama Soil. In: Proceedings to the 29th Annual Conference of the Soil Science Society of Nigeria.

Young A. (1976): Tropical soils and Soil survey, Cambridge University Press, Cambridge.